# CHEMICALS

**Project Fact Sheet**

# Novel Membrane Reactor for Fischer-Tropsch Synthesis

## Benefits

- Global economic benefits
- More efficient use of remote natural gas
- Decreases oil importation expenditures
- Significantly reduces FTS reactor volume

## Applications

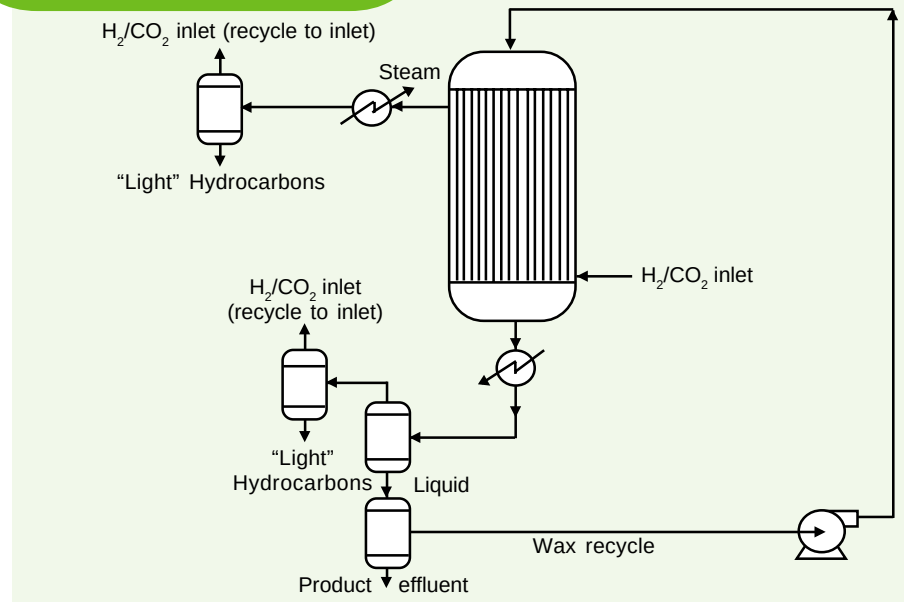
The primary application for this reactor technology is the conversion of remote natural gas, through synthesis gas, to liquid hydrocarbons.

## New membrane reactor technology for Fischer-Tropsch synthesis increases production capacity

A key barrier to reducing U.S. dependence on oil imports is our limited access to remote or stranded natural gas, which makes up roughly 60 percent of the world's proven reserves. Fischer-Tropsch synthesis (FTS) technology can help facilitate the cost-effective extraction and processing of these reserves. FTS is commonly used to produce liquid fuels and chemicals from natural gas and coal. However, current commercially available FTS membrane reactor designs (fixed-bed, tube-wall, fluidized-bed, and slurry) exhibit relatively low productivities per unit volume of reactor and, thus, require extremely large reactor volumes on the commercial-scale. For remote and off-shore natural gas applications, high reactor production capacity is required to minimize the costs associated with off-shore space limitations.

Project partners are developing a membrane reactor technology that will allow FTS reactors to be built at the same cost as traditional reactors, but with one-third of the reactor volume. This smaller equipment size enables the FTS membrane reactor to be used advantageously at remote and off-shore sites to convert natural gas streams into more easily transportable hydrocarbon liquids. The novel membrane reactor developed by project partners will: immobilize the catalyst; integrate heat recovery; minimize pressure drop and mass transport resistances; improve radial and axial gas mixing throughout the reactor; minimize catalyst attrition losses; eliminate independent unit operations for catalyst/product separation; and markedly increase productivity per unit reactor volume.

Fischer-Tropsch Synthesis




**Schematic of the proposed membrane reactor for Fischer-Tropsch synthesis.**

## Project Description

**Goal**: The goal of this project is to develop a novel membrane reactor for Fischer-Tropsch synthesis (FTS) that solves technical concerns in current reactor designs and increases reactor production capacity to 12,000 kg $C_2$+ per $m^3$ of reactor volume per day.

## Progress and Milestones

Early stage research resulted in the following findings:

- FTS catalysts can be applied to supported, microporous membranes
- FTS catalyst-coated membranes are attrition-resistant when subjected to hot, circulating, hydrocarbon liquids
- The flux of $H_2$ and CO through the membrane structure can be engineered to minimize bulk mass transfer resistances in the reactor
- A prototype, single-element membrane reactor is active for FTS and can, in principle, be scaled-up using project partners' patented membrane and monolith technologies

Current research is focused on achieving the following milestones:

- Complete experimental measurement of catalyst performance (intrinsic reaction rates, selectivity, and stability) in the absence of all heat and mass transfer limitations for each catalyst in the bench-scale, tubular, fixed-bed reactor
- Develop a kinetic model that adequately describes catalyst performance under commercially relevant process conditions
- Develop a catalyst-coated, membrane-coated substrate that exhibits the desired characteristics for the nominal catalyst layer, molecular fluxes, and attrition loss
- Develop an empirical or theoretical model which describes the selective permeance of $H_2$ and CO through the catalyst-coated, membrane-coated substrate
- Develop a robust empirical and/or theoretical model that integrates reaction kinetics, mass transfer, heat transfer and hydrodynamics
- Complete continuous operation of a bench-scale membrane reactor at a production capacity of 12,000 kg $C_2$+ per $m^3$ of reactor volume per day

## Commercialization

CeraMem Corporation currently has a contingent commitment for development and commercialization of the membrane reactor product from Syntroleum Corporation.

### Project Partners

CeraMem Corporation
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Manhattan, KS

University of Massachusetts at Amherst
Amherst, MA

Syntroleum Corporation
Tulsa, OK


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September 2001